SPH4U Formula and Data Sheet

Selected Physical Constants

Quantity	Symbol	Approximate Value
speed of light in a vacuum	c	2.99792458×10^{8} m/s
universal gravitational constant	G	6.67384×10^{-11} Nm^2kg^{-2}
Coulomb's constant	k	8.9879552×10^{9} Nm^2C^{-2}
charge on a proton	e	1.6022×10^{-19} C
electron rest mass	m_e	9.1094×10^{-31} kg
proton rest mass	m_p	1.6726×10^{-27} kg
neutron rest mass	m_n	1.6749×10^{-27} kg
atomic mass unit	u	1.6605×10^{-27} kg
electron volt	eV	1.6022×10^{-19} J
Planck's constant	h	6.6261×10^{-34} J·s
Permeability of Free Space	μ_o	$4\pi \times 10^{-7}$ T·m/A
Permittivity of Free Space	ϵ_o	8.854×10^{-12} $C^2N^{-1}m^{-2}$
Avogadro's Number	N_A	6.022×10^{23}

Commonly Used Metric Prefixes

Prefix	Abbreviation	Meaning
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Indexes of Refraction for Selected Materials

Substance	Refractive Index
vacuum	1.00000
air	1.00029
ice	1.31
water	1.333
ethanol	1.36
turpentine	1.472
window glass	1.50
Plexiglas	1.51
crown glass	1.52
flint glass	1.66
zircon	1.923
diamond	2.417

Solar System Data

Object	Mass [kg]	Radius of Object [m]	Mean Orbital Radius [m]		Metal	Work Function (eV)
Sun	1.99×10^{30}	6.96×10^{8}	----------		Aluminum	4.25
Mercury	3.28×10^{23}	2.44×10^{6}	5.79×10^{10}		Barium	2.48
Venus	4.83×10^{24}	6.05×10^{6}	1.08×10^{11}		Cadmium	4.07
Earth	5.98×10^{24}	6.38×10^{6}	1.49×10^{11}		Calcium	3.33
Mars	6.37×10^{23}	3.40×10^{6}	2.28×10^{11}		Cesium	1.90
Jupiter	1.90×10^{27}	7.15×10^{7}	7.78×10^{11}		Copper	4.46
Saturn	5.67×10^{26}	6.03×10^{7}	1.43×10^{12}		Mercury	4.50
Uranus	8.80×10^{25}	2.56×10^{7}	2.87×10^{12}		Nickel	5.01
Neptune	1.03×10^{26}	2.48×10^{7}	4.50×10^{12}		Potassium	1.60
Pluto	1.30×10^{23}	1.15×10^{6}	5.91×10^{12}		Sodium	2.26
Moon	7.35×10^{22}	1.74×10^{6}	3.84×10^{8}		Tungsten	4.52
					Zinc	3.31

Kinematics

$g = 9.8 m/s^2 = 9.8 N/kg$

$\overrightarrow{\Delta d} = \frac{1}{2}\vec{a}(\Delta t)^2 + \vec{v}_1 \Delta t$

$\overrightarrow{\Delta d} = -\frac{1}{2}\vec{a}(\Delta t)^2 + \vec{v}_2 \Delta t$

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$

$\overrightarrow{\Delta d} = \left(\frac{\vec{v}_1 + \vec{v}_2}{2}\right)\Delta t$

$v_2{}^2 = v_1{}^2 + 2a\Delta d$

$\vec{a}_c = \frac{v^2}{r}(\hat{r})$

$\vec{a}_c = 4\pi^2 r f^2 (\hat{r})$

$\vec{a}_c = \frac{4\pi^2 r}{T^2}(\hat{r})$

$\vec{v}_{AC} = \vec{v}_{AB} + \vec{v}_{BC}$

$R = \frac{v^2 \sin 2\theta}{g}$

$R = \frac{2v^2 \sin\theta\cos\theta}{g}$

$H = \frac{v^2 \sin^2\theta}{2g}$

$\Delta t = \frac{2v\sin\theta}{g}$

Dynamics

$\vec{F} = m\vec{a}$

$\vec{F}_c = ma_c(\hat{r})$

$\vec{F}_g = \frac{GM_1M_2}{r^2}(-\hat{r})$

$\vec{F}_g = m\vec{g}$

$\mu_s = \frac{F_s(\max)}{F_N}$

$\mu_k = \frac{F_k}{F_N}$

$F_{fr} = \mu F_N$

Relativity

$\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$

$L_m = \frac{L_s}{\gamma}$

$\Delta t_m = \gamma \Delta t_s$

$m = \gamma m_o$

$E = mc^2$

$E_k = mc^2 - m_o c^2$

Energy and Momentum

$W = \vec{F}\cdot\overrightarrow{\Delta d}$

$W = F\Delta d\cos\theta$

$E_g = mgh$

$E_g = -\frac{Gm_1m_2}{r}$

$E_k = \frac{1}{2}mv^2$

$E_e = \frac{1}{2}k(\Delta x)^2$

$k = \frac{F}{\Delta x}$

$T = 2\pi\sqrt{\frac{m}{k}}$

$T = 2\pi\sqrt{\frac{L}{G}}$

$T = 2\pi\sqrt{\frac{x}{a}}$

$x = A\sin\frac{2\pi t}{T}$

$\vec{J} = \vec{F}\Delta t = \Delta\vec{p}$

$\vec{p} = m\vec{v}$

$\vec{p} = m_1\vec{v}_1 + m_2\vec{v}_2 + \ldots$

$p_x = p_{1x} + p_{2x} + \ldots.$

$p_x = |\vec{p}|\cos\theta, etc.$

$v_1' = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_1$

$v_2' = \left(\frac{2m_1}{m_1 + m_2}\right)v_1$

Celestial Mechanics

$\vec{g} = \frac{GM}{r^2}(-\hat{r})$

$v_{orbital} = \sqrt{\frac{GM}{r}}$

$K = \frac{r^3}{T_2} = \frac{GM}{4\pi^2}$

$v_{escape} = \sqrt{\frac{2GM}{r}}$

$E_g = -\frac{GMm}{r}$

$R_{sch} = \frac{2GM}{c^2}$

$\Delta E = -GM\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$

Electrostatics

$\vec{F}_E = \frac{kq_1q_2}{r^2}(\hat{r})$

$\vec{\varepsilon} = \frac{kq}{r^2}(\hat{r})$

$E_E = \frac{kq_1q_2}{r}$

$V = \frac{kq}{r}$

$\Delta E = q\Delta V$

$q = Ne$

Electromagnetism

$\vec{F}_M = q\vec{v}\times\vec{B}$

$|\vec{F}_M| = qvBSin(\theta)$

$F = I\ell BSin(\theta)$

$B = \frac{\mu_o I}{2\pi r}$

$B = \frac{\mu_o NI}{L}$

Light

$v = f\lambda$

$\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$n_1\sin\theta_1 = n_2\sin\theta_2$

$n_{1\to2} = \frac{v_1}{v_2}$

$n_{1\to2} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$

$|P_nS_1 - P_nS_2| = \left(n - \frac{1}{2}\right)\lambda$

$\sin\theta_n = \frac{x_n}{L} = \left(n - \frac{1}{2}\right)\frac{\lambda}{d}$

$\sin\theta_m = \frac{x_m}{L} = \frac{m\lambda}{d}$

$\frac{\Delta x}{L} = \frac{\lambda}{d}$

$\sin\theta_n = \frac{n\lambda}{w}$

$\sin\theta_m = \frac{\left(m + \frac{1}{2}\right)\lambda}{w}$

$n = \frac{c}{v}$

Matter-Energy Interface

$\lambda_{\max}T = 2.90\times10^{-3} mK$

$E = hf = \frac{hc}{\lambda}$

$E_k = hf - W$

$p = \frac{h}{\lambda} = \frac{E}{c}$

$\lambda = \frac{h}{mv}$

$E = mc^2$

$hf = (hf)' + E_k$